Making High Performance Computers Highly Productive

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Agenda

- What's the state of high end computing?
  - Certainly not the best of times
- What does "productivity" really mean?
  - Measurements?
- A few ideas on a way forward

What's right

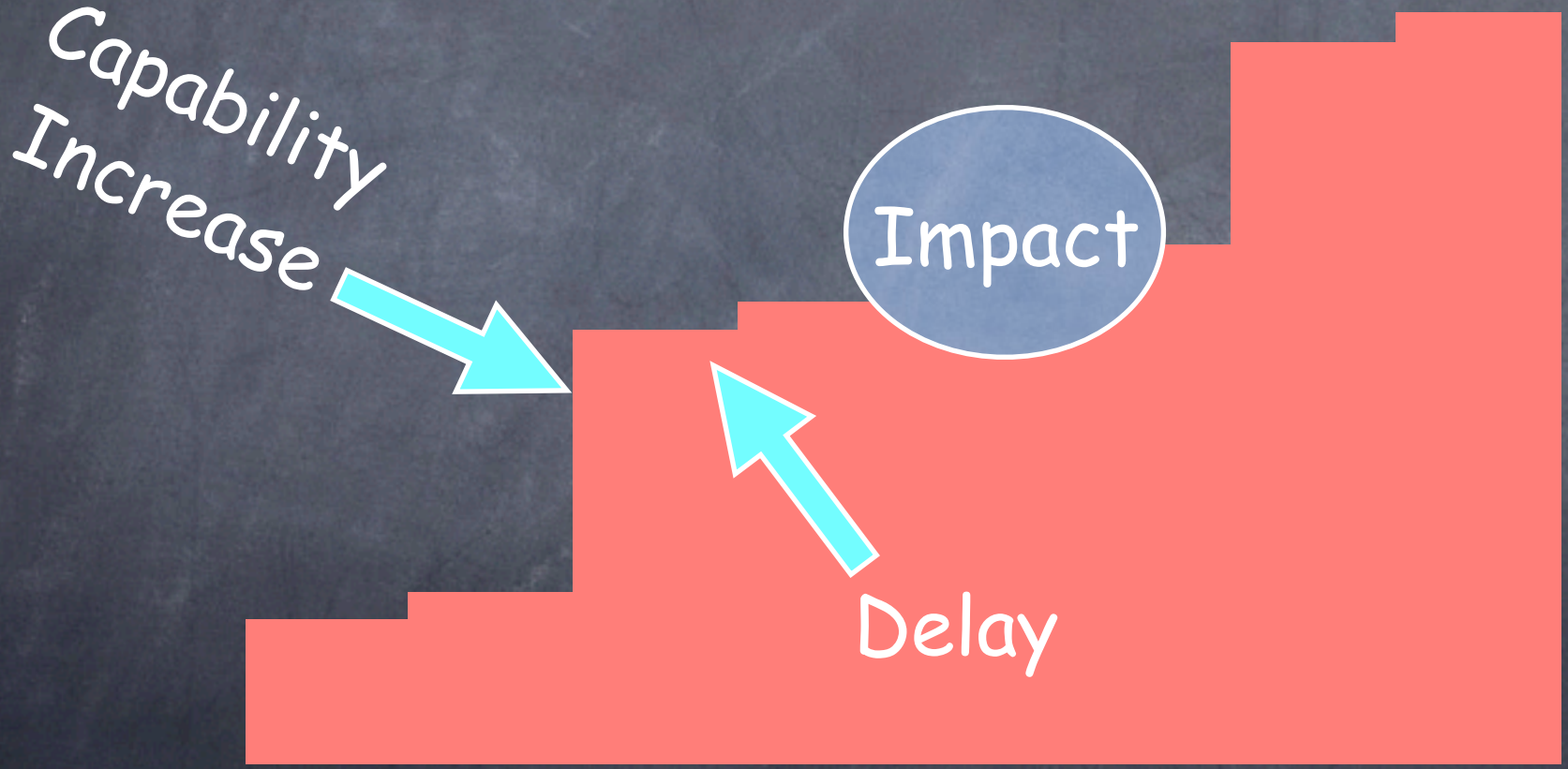
- We are getting many, many more cycles
  - With respect to ops, Moore rules
- Memory bandwidth is starting to improve
  - Cray X1, Alpha EV7, Opteron, Others
- We are getting some new applications
  - But not enough

What's Wrong

- Still no stable market
- Programming time is increasing
  - No real solution for parallel programming
- Decreasing Numbers:
  - Users
  - Programmers
  - Institutions who care

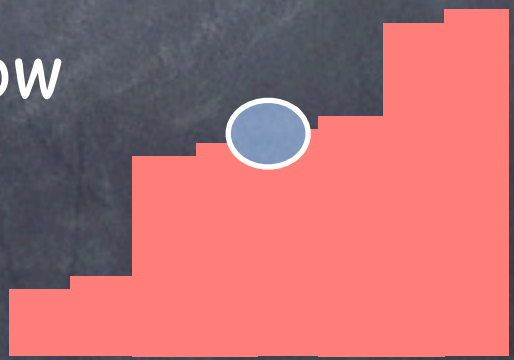
Capability Profile

The Impact Zone

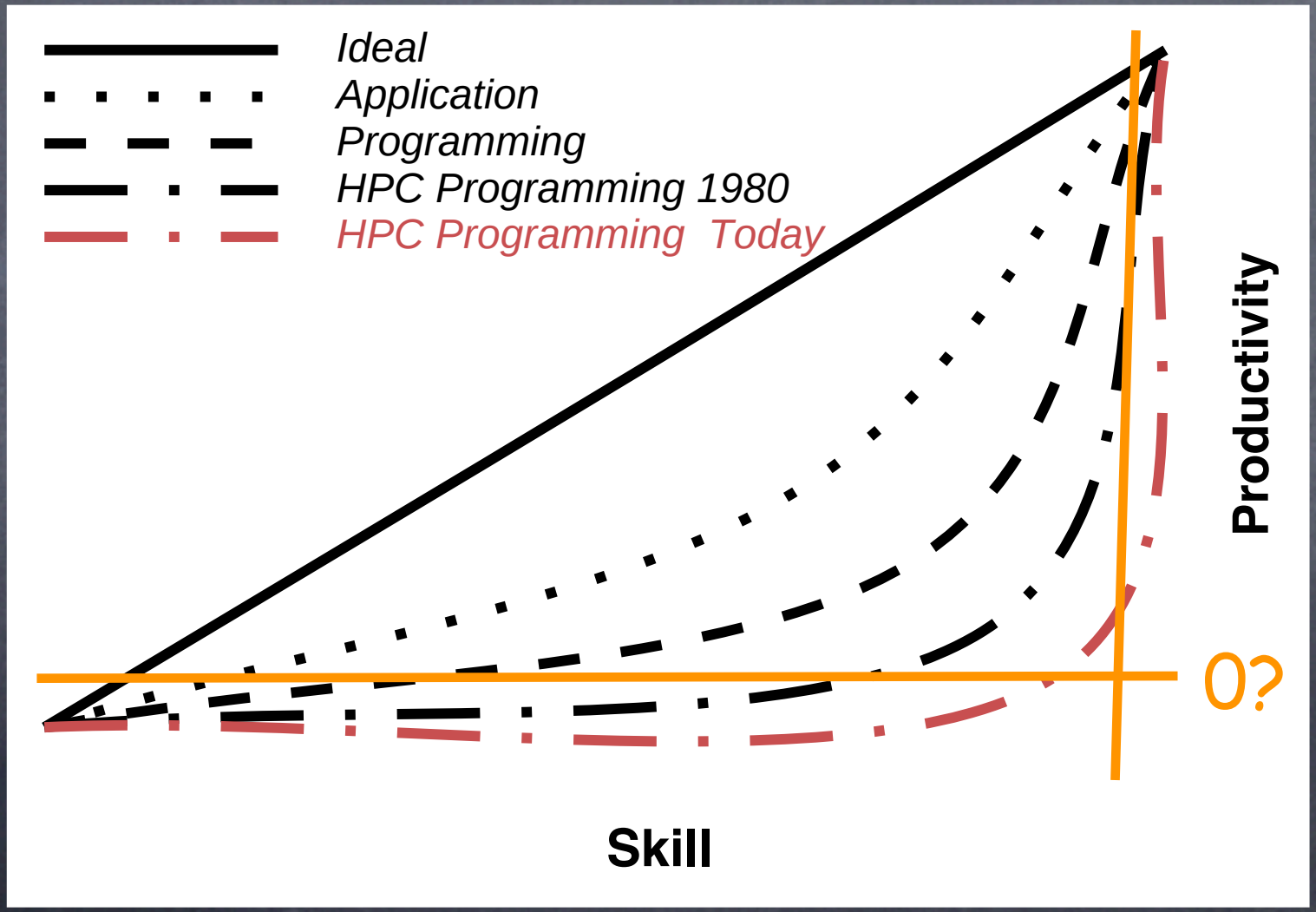


Observations and Trends

- Delay to impact zone is too long
  - And growing
- Length of impact zone is short
  - Excitement wanes quickly
- Depth of impact zone is shallow



Productivity Today



Productivity

- Make the impact zone sooner, longer, deeper
- Economics 101: Output per unit of input
  - GDP per unit labor-hour
  - Output is not ops, but impact
  - Input is not just $, but human capital
- Real output of HPC is Understanding
  - Need to find the GDP for our field!

Measuring is Hard

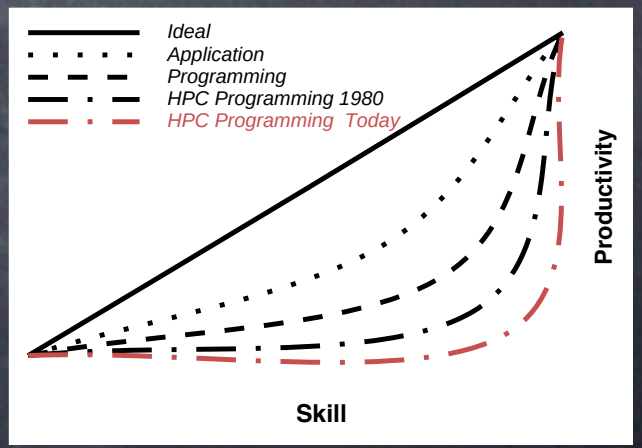
- Programming time:
  - Usually measured in SLOC/time
  - This is good for project managers
  - Very BAD for trying to tune productivity
    - presumes constant level of abstraction
- OK, measuring run time is "easy"
- Interpretation time?
- All DEPENDENT variables!

One Measurement Idea

- Computational Mass/Action (Bob Numrich)
  - Physics isomorphism:
    - work,distance,time -> ops, bits, hz
    - computational mass is derived: ops/(bit-hz)^2
  - Newton's Laws (and much of physics) can be used!
- Programming and Interpretation Work
  - Code/Data represented has some mass
  - Force needed to move from "bad" "location" to "good"
- Needs work, but hope for unification

A way forward

- Scientific Productivity Stewardship?
- Use science and engineering to guide us
  - Research: New ideas!
  - Vendors: Prototypes VERY Important!
  - Government: Getting it together
    - DARPA HPCS
    - IHEC, NAS study, HEC/RTF



Some Initial Ideas

- Abstraction
  - Type less, reuse more
- Persistence
  - Data lives a long time, why not use it?
- Diversity of Expression
  - No one right way to say everything

Abstraction

- Not just about "object oriented" languages
  - Abstraction about parallelism (UPC)
  - Abstraction about functionality (MatLab)
  - Abstraction about data (Transactions)
- Abstraction can't mean low performance!
  - Runtime a big component of productivity
- Re-Use

NOT only software!

- Architecture
  - More than "shared memory" or "message passing"
- Hardware Assist
  - Better latency/bandwidth always needed
  - Content addressable memory?

Persistence

- Some early experiments are encouraging
  - "Data Mining" and "Object Stores"
- Databases integrated with simulations
- Persistence as a parallel model
  - Transactions help tolerate both latency and faults (both hardware and software)

Integration

- Procedural programming
  - Tell the computer the order to execute
  - Much research on integration here (babel)
- Declarative programming
  - Tell the computer what you want (SQL)
- Never work well together

An Example - "autosql"

- Establish correlation between database tables and data structures in memory.
- "Queries" and "Updates" in database are now automatic (Abstraction)
- Program can "live" forever (Presistence)
  - Automatic checkpoint and restore
- Many instances leads to parallel program
  - Database could be integrated with program

autosql example

```
struct mine t {int a, time_t b, double d);
struct auto_sql tbl { "select a,b from c",
  {"a", A_INT, A_OFF (t,a)},
  {"b", A_DATE, A_OFF (t,b)}};

as = as_open (postgres:test);
dp = as_select (as, &tbl, "where d > %g", 1.4);
if (dp) {
  struct mine *t = dp->data;

  for (i=0; i<dp->n; i++)
    {
      printf ("a:%d b:%s\n", t->a, ctime(t->b));
      t++;
    }
}
```

Summary

- High Performance computing is in trouble
  - Not because of performance growth
  - Simply not "productive" enough
- There is a way forward
  - Abstraction, Persistence, Integration
- I, for one, will start this journey
  - Please join me!